Departamento de Astrofísica y Ciencias de la Atmósfera
Grupo de Astrofísica Extragaláctica e Instrumentación Astronómica

# *PySQM the UCM open source software to read, plot and store data from SQM photometers*

Authors: Miguel Nievas & Jaime Zamorano

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**Abstract**

A multi platform software (PySQM) has been designed to read, store and plot data from Unihedron SQM-LE and SQM-LU photometers. It is intended to record night sky brightness data obtained with fixed SQM photometers. PySQM is distributed as open source software.

## 1. Introduction

The Sky Quality Meter (SQM) photometers are simple and reliable devices that are intended to measure the night sky brightness (NSB) with a precision around ~0.1 mag/arcsec$^2$ as stated by the manufacturer [1] (http://www.unihedron.com) and tested by several studies ([2], [3], [4], [5]). They have in addition a very wide dynamic range, of more than 10mag/arcsec2, which makes them suitable to study the sky brightness under very different conditions. The SQM photometers are also user friendly and not expensive. All these characteristics have made the SQM very popular and it has become a de facto standard device used by many researchers and people interested in light pollution studies.

Besides the SQM-L photometers, designed for hand held measures, there are some models whose data can be read from a computed connected via USB link (SQM-LU) or a LAN cable (SQM-LE). The information about the reading protocol is provided by Unihedron and there are some software available like *SQM Reader*, a free program that reads and displays data from SQMs, and *SQM Reader Pro* which has more features, both from Knightware (http://knightware.biz/sqm/index.htm).

Some research groups are setting SQM networks to monitor night sky brightness with the aim of studying the NSB evolution ([6], [7], [8]). There is an increasing interest in comparing measurements from different sites, and to develop databases containing long term measurements from around the world. This is why at the Cabauw Lightmeter InterComparison (CLIC) workshop in May 2012, a group of light pollution researchers defined a proposal for a new, standard format to be used for recording skyglow measurement. The "NSBM Community Standards for Reporting Skyglow Observations" was officially adopted at the 12th European Symposium for the Protection of the Night Sky and endorsed by The International Dark Sky Association (IDA) and also by the International Astronomical Union (IAU) in Beijing 2012 (SpS17: "Light Pollution: Protecting Astronomical Sites and Increasing Global Awareness

through Education") (extracted from IDA webpage http://www.darksky.org/night-sky-conservation/248).

The ascii files (one for each night) should include a header and the NSB data (including date and time) with an standard format. A preliminary version of this standard was defined at the Cabauw Lightmeter Inter Comparison Workshop in May, 2012 and the first version is described in [9, 10]

We have written PySQM as a multi-platform, open-source software designed to read and plot data from Unihedron SQM-LE and SQM-LU photometers, giving as an output files with the IDA and IAU NSB standard format.

PySQM is distributed under GNU GPL, either version 3 of the License, or (at your option) any later version. See the file LICENSE.txt for details. This software has been developed by Miguel Nievas (UCM) with the invaluable help of: Jaime Zamorano (UCM), Laura Barbas (OAN) & Pablo de Vicente (OAN).

## 2. How it works

In a first step, the program tries to connect to the SQM photometer and takes some 'tests' measures (metadata/information, calibration and data) to check that the device is working as expected. These calibration measures are added to the NSB file header, prior to the real data. After that, the program begins data acquisition. In every iteration, it checks whether it is night time or not by calculating the sun altitude for the given location and comparing with an user defined threshold. In that case new data is taken and stored in 2 different files, the first for the current night and the last one for the accumulated monthly data. The main program calls a plotting function every N measurements to generate a graphical representation of the current nightly data. The results for some SQM devices in Spain can be browsed at http://guaix.fis.ucm.es/SQM-UCM

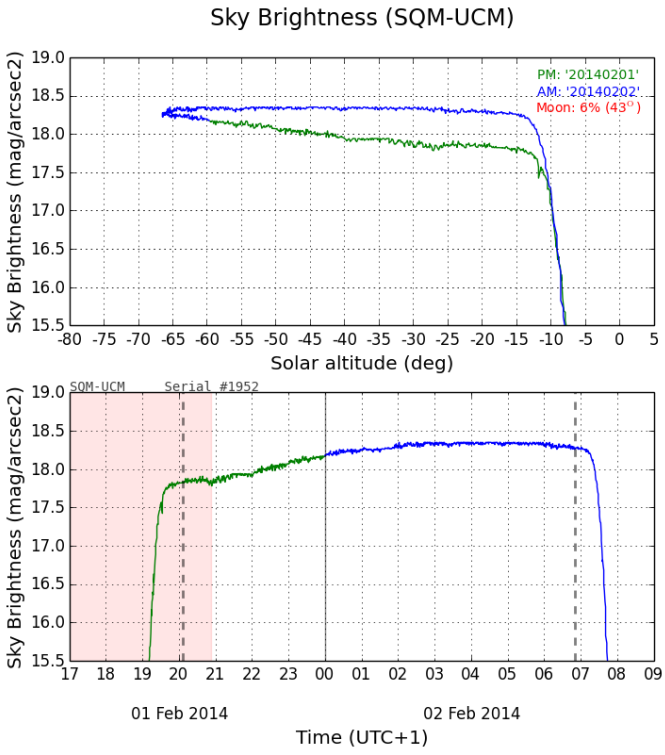


Figure 1: Plot of the night 2013 September 01 to 02 for the SQM located at Observatorio UCM obtained with PySQM. Night sky brightness in magn/arcsec2 versus time (lower panel) and versus solar altitude (upper panel). During a typical night the sky is darker in the second part of the night when the human activity is lower and some ornamental lights are switched off. The pink shadow indicates the presence of the Moon over the horizon. Higher NSB values mean darker skies.

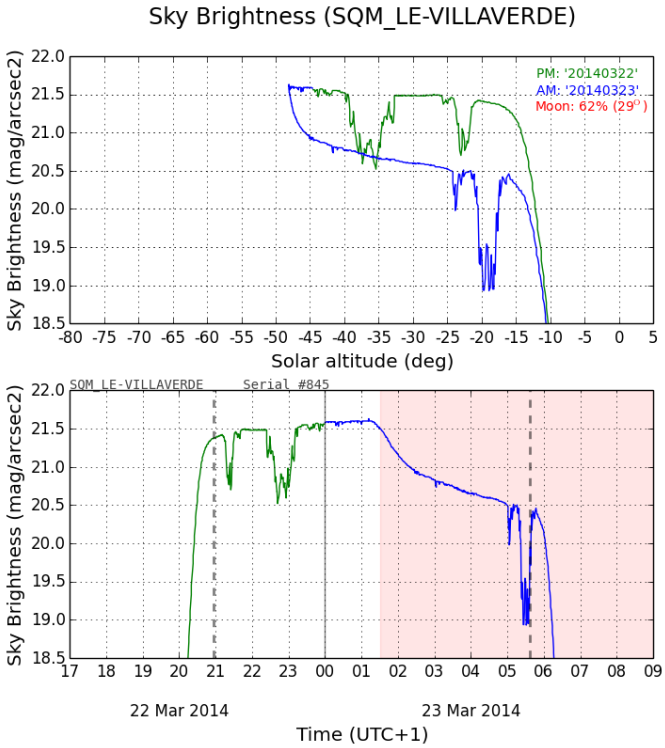


Figure 2: Plot of the night 2014 March 22 to 23 for the SQM located at Villaverde del Ducado (a small village in a rural area 130 km from Madrid). The night sky is darker than Madrid's sky, as expected. Some episodes of clouds during the night are clearly marked as a brightening of the sky. When the Moon rises the sky brightens. Dashed vertical lines correspond to the astronomical twilight.

Part of the data file for the night plotted in figure 2 follows:

```
# Definition of the community standard for skyglow observations 1.0
# URL: http://www.darksky.org/NSBM/sdf1.0.pdf
# Number of header lines: 35
# This data is released under the following license: ODbL 1.0
http://opendatacommons.org/licenses/odbl/summary/
# Device type: SQM-LE
# Instrument ID: SQM_LE-VILLAVERDE
# Data supplier: Jaime Zamorano / Universidad Complutense de Madrid
# Location name: Villaverde del Ducado/Spain - Observatorio VILLAVERDE
# Position: 41.002703, -2.490978, 1100
# Local timezone: UTC+1
# Time Synchronization: NTP
# Moving / Stationary position: STATIONARY
# Moving / Fixed look direction: FIXED
# Number of channels: 1
# Filters per channel: HOYA CM-500
# Measurement direction per channel: 0., 0.
# Field of view: 20
# Number of fields per line: 6
# SQM serial number: 845
# SQM firmware version: 14
# SQM cover offset value: -0.11
# SQM readout test ix: i,00000004,00000003,00000014,00000845
# SQM readout test rx: r, 14.61m,0000000117Hz,0000003598c,0000000.008s, 018.3C
# SQM readout test cx: c,00000019.88m,0000300.000s, 025.7C,00000008.71m, 029.0C
# Comment:
# Comment:
# Comment:
# Comment:
# Comment: Capture program: PySQM
# blank line 30
# blank line 31
```

```
# blank line 32
# UTC Date & Time, Local Date & Time, Temperature, Counts, Frequency, MSAS
# YYYY-MM-DDTHH:mm:ss.fff;YYYY-MM-DDTHH:mm:ss.fff;Celsius;number;Hz;mag/arcsec^2
# END OF HEADER
2014-03-22T17:28:01.000;2014-03-22T18:28:01.000;21.20;0.000;535487.250;-0.000
2014-03-22T17:28:43.000;2014-03-22T18:28:43.000;21.20;0.000;535492.250;-0.000
2014-03-22T17:29:25.000;2014-03-22T18:29:25.000;21.20;0.000;535514.200;-0.000
-----
2014-03-22T20:40:19.000;2014-03-22T21:40:19.000;15.40;1785195.250;0.258;21.370
2014-03-22T20:41:01.000;2014-03-22T21:41:01.000;15.40;1916379.600;0.240;21.458
2014-03-22T20:41:43.000;2014-03-22T21:41:43.000;15.40;1944375.250;0.237;21.470
2014-03-22T20:42:25.000;2014-03-22T21:42:25.000;15.40;1966964.000;0.234;21.480
2014-03-22T20:43:06.000;2014-03-22T21:43:06.000;15.40;1953631.000;0.236;21.480
2014-03-22T20:43:48.000;2014-03-22T21:43:48.000;15.40;1969286.250;0.234;21.490
2014-03-22T20:44:30.000;2014-03-22T21:44:30.000;15.40;1981012.333;0.233;21.490
2014-03-22T20:45:12.000;2014-03-22T21:45:12.000;15.40;1974723.500;0.233;21.492
2014-03-22T20:45:54.000;2014-03-22T21:45:54.000;15.40;1981154.333;0.233;21.490
------
2014-03-22T22:40:06.000;2014-03-22T23:40:06.000;13.20;2055410.750;0.224;21.532
2014-03-22T22:40:48.000;2014-03-22T23:40:48.000;13.20;2083115.333;0.221;21.550
2014-03-22T22:41:30.000;2014-03-22T23:41:30.000;13.20;2100927.333;0.219;21.560
2014-03-22T22:42:12.000;2014-03-22T23:42:12.000;13.20;2043240.000;0.226;21.522
------
2014-03-23T07:03:52.000;2014-03-23T08:03:52.000;12.20;0.000;534058.400;-0.000
2014-03-23T07:04:34.000;2014-03-23T08:04:34.000;12.50;0.000;534042.400;-0.000
2014-03-23T07:05:16.000;2014-03-23T08:05:16.000;12.50;0.000;534002.000;-0.000
2014-03-23T07:05:58.000;2014-03-23T08:05:58.000;12.50;0.000;534046.667;-0.000
```

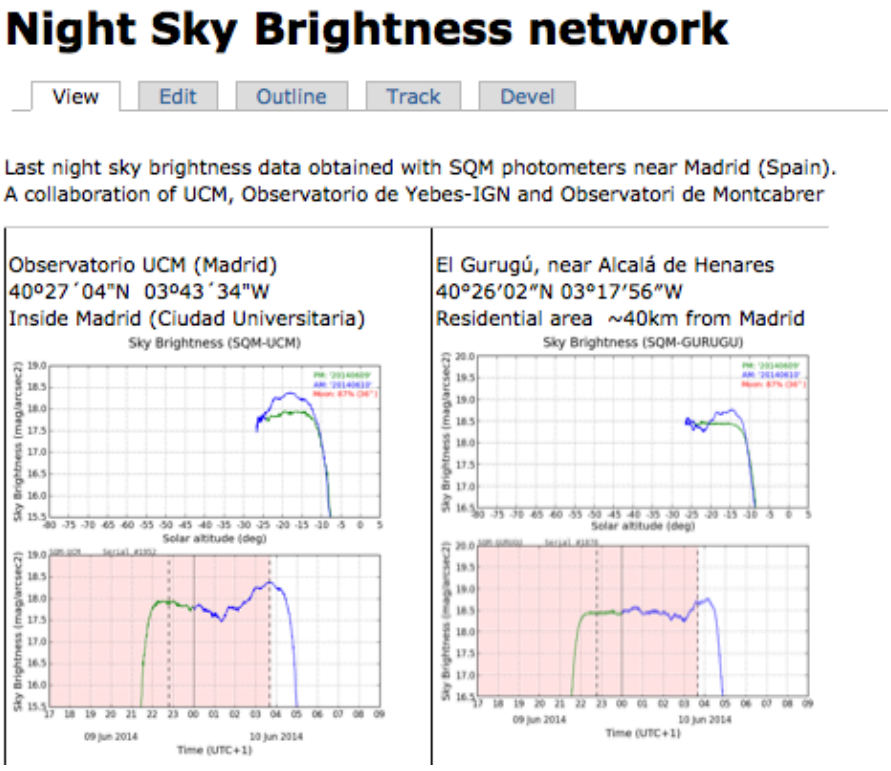


Figure 3. : The plots of some two SQM located at Observatorio UCM and near Alcalá de Henares for the same night obtained with PySQM at http://guaix.fis.ucm.es/SQM-UCM

## 3. Software setup

After downloading the software, you need to modify the file pysqm/config.py. In this file you will find several variables that need to be configured to match your hardware settings. For example:

- Location of the observatory (geographical coordinates).
- Device identifier.
- Device address (either IP address for SQM-LE or COM/ttyUSB port).
- Location of the data files.
- Axis limits for the plot.

Remember that python (2.7) syntax is mandatory in this file. The configuration file for Villaverde del Ducado SQM-LU is reproduced as an example

```
#!/usr/bin/env python
'''
PySQM reading program
Configuration File
'''

'''
Configuration variables.
Change it as needed for your observatory.
NOTE: Python syntax is mandatory.
'''
_observatory_name = 'VILLAVERDE'
_observatory_latitude  = 41.002703
_observatory_longitude = -2.490978
_observatory_altitude  = 1100
_observatory_horizon   = 10     # If Sun is below this altitude, the program will
take data
_device_shorttype = 'SQM_LU'   # Device STR in the file
_device_type = 'SQM_LU'        # Device type in the Header
_device_id = _device_type + '-' + _observatory_name # Long Device lame
_device_locationname = 'Villaverde del Ducado/Spain - Observatorio VILLAVERDE'
# Device location in the world
_data_supplier = 'Jaime Zamorano / Universidad Complutense de Madrid'  # Data
supplier (contact)
_device_addr = 'COM7'  # Default IP address of the ethernet device (if not
automatically found)
_measures_to_promediate = 5     # Take the mean of N measures
_delay_between_measures = 20    # Delay between two measures. In seconds.
_cache_measures = 5             # Get X measures before writing on screen/file
_plot_each = 60                 # Call the plot function each X measures.
_use_mysql = False        # Set to True if you want to store data on a MySQL db.
_mysql_host = None        # Host (ip:port / localhost) of the MySQL engine.
_mysql_user = None        # User with write permission on the db.
_mysql_pass = None        # Password for that user.
_mysql_database = None    # Name of the database.
_mysql_port = None        # Port of the MySQL server.

_local_timezone     = +1     # UTC+1
_computer_timezone  = +0     # UTC
_offset_calibration = -0.11  # magnitude = read_magnitude + offset
_reboot_on_connlost = False  # Reboot if we loose connection

# Monthly (permanent) data
monthly_data_directory = "C:/Users/Jaime/Dropbox/sqm_villaverde/SQM_LU/"
# Daily (permanent) data
daily_data_directory   = monthly_data_directory+"/datos_diarios/"
```

```
# Daily (permanent) graph
daily_graph_directory = monthly_data_directory+"/graficos_diarios/"
# Current data, deleted each day
current_data_directory = monthly_data_directory
# Current graph, deleted each day.
current_graph_directory = monthly_data_directory
# Summary with statistics for the night
summary_data_directory = monthly_data_directory

'''
Ploting options
'''

limits_nsb = [18.5,22.0] # Limits in Y-axis
limits_time   = [17,9] # Hours
limits_sunalt = [-80,5] # Degrees

'''
Email options
'''
_send_data_by_email = False
```

## 4. How to run PySQM

After configuring the software, make sure you are in the parent directory were the README, LICENSE and MANIFEST files are located > ls LICENSE.txt MANIFEST.in README.txt pysqm setup.py And then run the software.

```
> python -m pysqm
```

The program should find your SQM device and the data acquisition will start (if it's night-time). In some systems, where python3 is the default version of python, you need to specify python2 as the interpreter to use. This is done usually running it as:

```
>  python2 -m pysqm
```

or (if you have more than one versions of python2),

```
> python2.7 -m pysqm
```

Note: running the setup.py script is neither tested nor necessary at the moment. The program is currently being redesigned as a normal python package, but at present no setup is required.

There is an additional way of running PySQM, only available for Microsoft Windows platforms now, by using the selft-contained PySQM.exe file. It contains both the program and the Python interpreter, so it is no need to set up python 2.7. In this case, only two files are needed: the executable PySQM.exe and the configuration file config.py. Both files should be stored in the same directory.

## 5. PySQM output

The measurements taken by the connected SQM are displayed in the console along with the date and time. Periodically, a new NSB plot is generated. At the same time NSB plot is generated and can be displayed in real time. The same is true for the standard file with the measurements. At any time of the night there is a provisional ascii file a png image with the data up to this time. At the end of the night these files

with all the data for the night are closed. The files are named using the date and location name (for instance 20131017_1200000_SQM_LU-VILLAVERDE.dat and .png) and they are stored in dedicated directories. PySQM also yield a monthly file including the data for all the nights of the month.

## 6. PySQM download

If you wish to use it, please download the PySQM software from the PySQM webpage: http://guaix.fis.ucm.es/PySQM

## 7. Final remarks

More info including known issues, FAQ and troubleshooting in the PySQM info page http://guaix.fis.ucm.es/PySQM_info

## References


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